

DESIGN AND FABRICATION OF CUTTING-EDGE PLASTIC BOTTLE CAP PRESS TOOLS FOR A GREENER FUTURE

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Abstract

Waste is the result of human activity which puts great pressure on the environment, especially when waste is not collected and ends up piling up in open places and water bodies. Waste management can generally be done by burning it, throwing it into ditches, landfilling it and most often throwing it into rivers. This design aims to deal with plastic waste by recycling it. The method used is a melting system using a microwave, while pressing uses a hydraulic jack. The use of this tool is to recycle the waste and process it into something that has use and sale value. The results of this bottle cap recycling tool convert plastic bottle cap waste into furniture material, in the form of coasters. The jack used in this tool has a capacity of 10 tons. In tests carried out on 125g bottle caps, they melted for 60 minutes at a temperature of 250°C.

Keywords: *design, fabrication, plastic bottle caps, press recycling dance*

Introduction

The impact of the increasing amount of plastic waste originating from beverage bottles has recently become a major concern in various environmental discussions, having a detrimental impact on the environment (Manjunatha et al., 2021). Plastic is difficult to decompose and research shows that the decomposition process takes around 50 million years (Admin, 2023). If there are no handling measures, the earth has the potential to become an environment consisting of rubbish and useless items. One potential that exists is the use of plastic waste to create creative products that have value (Zhao et al., 2022). The aim is to raise awareness of the importance of ecosystems and a proper understanding of waste management to protect the environment. By utilizing this plastic waste, we can reduce the amount of waste around us in our opinion.

In modern society, there is a habit where unused items, especially rubbish, continue to increase in number. To reduce the impact of the increase in wasted waste, efforts are needed to reduce the amount of waste that is wasted in the environment (Matthew, 2022). This effort is expected to be able to reduce negative impacts on health and the beauty of the environment. One step that can be taken is through waste recycling practices, such as collecting bottle caps which can later be turned into products such as tables or paving blocks so they can be reused. Through efforts to create a more organized

environment, it is hoped that it can raise environmental awareness and create a clean and comfortable environment.

Plastic bottle waste is included in the inorganic waste category which can be used as material for the recycling process (Aprilia et al., 2013). However, until now, there has been no effort from the community to deal with plastic bottle waste. Therefore, a recycling press tool is needed to manage waste from plastic bottle caps. The advantage of the plastic bottle cap waste management process is that it reduces the accumulation of bottle waste because of its small size, so it is more efficient in storage and has a high selling value.

The management process begins by melting the waste using a recycling press tool, but public understanding of how this tool works is still limited. Therefore, outreach and education regarding the use of this tool is needed. This tool can convert plastic bottle cap waste into material that is ready to be recycled, and this is very useful, especially for waste bank managers in the environment.

The use of plastic bottles has become an integral part of the modern lifestyle, especially in beverage packaging and other consumer products (Evode et al., 2021). However, the increasing use of plastic bottles also has a serious impact on the environment, especially in terms of environmental pollution and the accumulation of plastic waste (Putri et al., 2013). One way to overcome this problem is through the practice of recycling plastic bottles.

The plastic bottle recycling process involves a compaction stage, which requires compacting the plastic bottle caps so that the recycling process can be carried out efficiently. Therefore, it is necessary to have a recycling press tool that can simplify and increase efficiency in the compaction stage of plastic bottle caps before further processing. Research and development of this press recycling tool have become relevant because of the need to design innovative and efficient solutions in the plastic bottle recycling process (Ding & Zhu, 2023). It is hoped that this tool can contribute to reducing plastic waste, supporting recycling practices, and overall contributing to environmental preservation.

Through the design and fabrication of plastic bottle cap recycling press tools, it is hoped that reliable and practical solutions will emerge to improve the recycling process and motivate the public to be more proactive in supporting environmental sustainability. Thus, this research aims to create solutions that are environmentally friendly, and innovative, and can be widely adopted to help overcome the problem of plastic waste in the future.

Method

The design of plastic bottle cap recycling press tool is designed to carry out the melting process using a microwave and pressing using a hydraulic jack. The method applied uses SolidWorks software as a tool for designing and modelling structures and components in three-dimensional simulations, which are then analyzed. in-depth to understand the behaviour and performance of the system under study. The process of making this tool begins with cutting a 110 cm long U profile frame iron and 55 cm long iron supporting angles. The next step involves the assembly and drilling stages, followed by installing bolts on the drilled frame and the welding process on the iron frame. After this stage, the quality and robustness of the tool structure are checked before proceeding to the next stage in the manufacturing process.

Subsequently, the microwave melting component is carefully integrated into the designed structure. This component is strategically positioned to ensure optimal heat distribution for the melting process of plastic bottle caps. The incorporation of microwave technology not only facilitates the melting phase but also aligns with eco-friendly practices, as it minimizes energy consumption compared to traditional methods. The precise placement and fixation of the microwave component within the structure are crucial for achieving efficient and uniform melting.

The hydraulic jack system, another integral part of the tool, is meticulously installed to provide the necessary pressure for pressing the melted plastic. SolidWorks simulations play a pivotal role in analyzing the stress distribution and load-bearing capacity of the hydraulic system, ensuring its resilience under varying pressures. This step is crucial to guarantee the safety and stability of the tool during operation.

The control and monitoring system is implemented to regulate the entire process seamlessly. This includes temperature control for the microwave component and pressure regulation for the hydraulic jack. Sensors and actuators are strategically positioned to provide real-time feedback, allowing operators to make necessary adjustments and ensuring the tool operates within optimal parameters.

As the tool nears completion, a comprehensive testing phase is initiated to evaluate its performance. This involves trial runs with different types of plastic bottle caps to assess the tool's efficiency, reliability, and overall effectiveness in the recycling process. Any identified issues are addressed through iterative design modifications and improvements.

The design and fabrication of the plastic bottle cap recycling press tool represent a multidisciplinary approach, integrating engineering principles with environmental consciousness. The utilization of SolidWorks software, coupled with meticulous fabrication techniques, results in a sophisticated and reliable tool that addresses the pressing need for sustainable plastic waste management. This innovative solution aims not only to enhance the recycling process but also to inspire similar initiatives that contribute to a greener and more sustainable future.

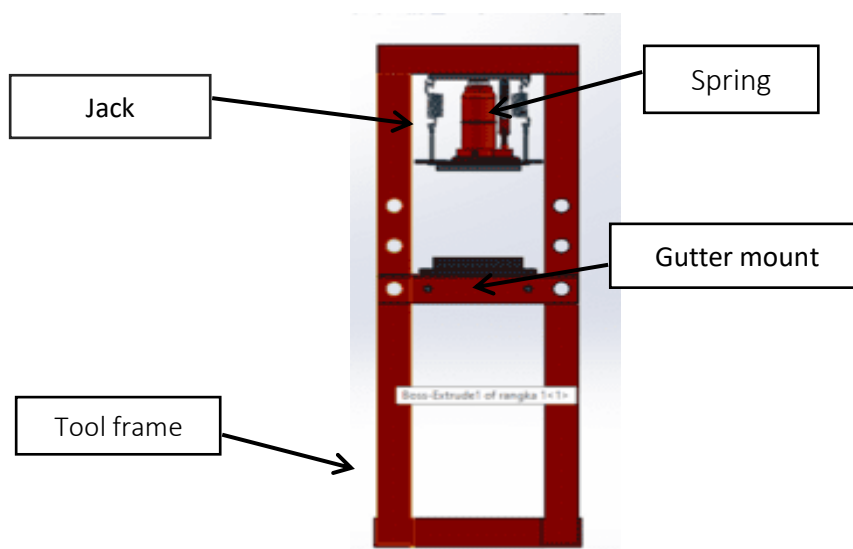


Figure 1 Recycle Press Tool Design

Result and Discussion

From the results of the design and fabrication of the press tool for recycling plastic bottle caps, as in Figure 2.

Mold Design

Following the fabrication of the press tool for recycling plastic bottle caps, the moulding stage emerges as a critical step in the overall recycling process. Once the plastic caps have undergone the melting process utilizing the integrated microwave component, the liquefied plastic is carefully poured into the prepared mould. The mould, specifically designed to accommodate the desired shape and dimensions, is then securely closed, encapsulating the molten plastic within its contours.

As the mould encloses, the plastic begins to fill the intricacies of the mould's structure. This stage is fundamental in determining the final form and specifications of the recycled plastic bottle caps. The precision of the mould design is paramount, ensuring that the recycled caps meet industry standards and specifications for reuse.

Subsequently, the press machine comes into action, exerting controlled pressure onto the closed mould. This pressing action serves multiple purposes in the recycling process. Firstly, it aids in shaping the plastic within the mould to conform precisely to the intended design. Secondly, the pressure promotes the cooling and solidification of the plastic within the mould, a crucial step in achieving the desired structural integrity.

The hydraulic press, a key component in this phase, operates with a careful balance of force and finesse, ensuring that the recycled plastic caps maintain uniformity and structural strength. SolidWorks simulations prove instrumental in optimizing the pressing process, allowing for a thorough analysis of stress points and load distribution to prevent deformities and inconsistencies in the final product.

Quality control measures are rigorously implemented throughout this stage, with constant monitoring of variables such as temperature, pressure, and moulding time. Any deviations from the predefined parameters trigger immediate adjustments to maintain the integrity and quality of the recycled plastic caps.

The moulding and pressing stages represent the culmination of the design and fabrication efforts, translating theoretical concepts into a tangible and efficient recycling process. This innovative approach not only addresses the environmental challenges posed by plastic waste but also showcases the successful integration of technology and engineering in creating sustainable solutions for a greener future. The refined recycled plastic bottle caps produced through this process stand as a testament to the efficacy of the designed press tool in contributing to a circular economy and minimizing the environmental impact of plastic consumption.

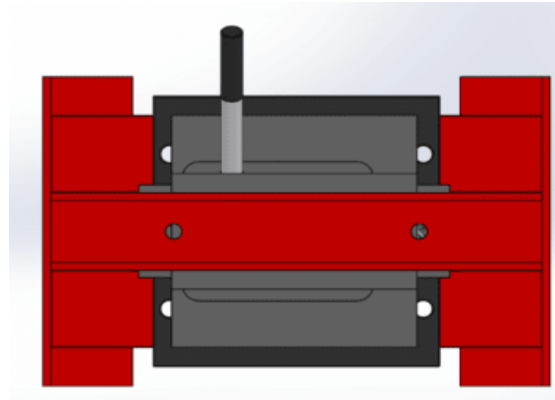


Figure 2 Top view of The Recycling Press Mold Design

Fabrication

The plastic bottle cap press fabrication process goes through a series of steps to produce an accurate shape that meets the required specifications. The selection of suitable materials for mould manufacturing includes high alloy steel and stainless steel, depending on the requirements of precision, durability and high-temperature resistance. Once the initial machining is complete, a post-machining process is required to obtain the required smoothness. This includes smoothing the surface and adding other desired details.

After the initial machining of the moulds for the plastic bottle cap press fabrication, a meticulous post-machining process is undertaken to enhance the precision and surface finish, ensuring that the final product adheres to the required specifications. This critical stage involves several steps to achieve the desired smoothness and other intricate details essential for the functionality and aesthetics of the recycled plastic bottle caps.

The first step in the post-machining process involves surface smoothing to eliminate any imperfections or irregularities resulting from the initial machining. This is typically achieved through techniques such as polishing, grinding, or sanding, depending on the specific requirements of the mould. The goal is to create a flawlessly smooth surface on the mould, enhancing its functionality and contributing to the overall quality of the recycled plastic caps.

Furthermore, additional details and features required for the specific design of the plastic bottle caps are incorporated during this post-machining phase. These details may include embossed logos, texture patterns, or any other unique characteristics that contribute to the aesthetic appeal and functionality of the final product. Precision in adding these details is crucial to ensure uniformity and consistency across all recycled caps produced using the mould.

The choice of materials for mould manufacturing, such as high alloy steel and stainless steel, plays a pivotal role in determining the success of the post-machining process. High alloy steel is preferred for its exceptional hardness and resistance to wear, making it suitable for prolonged use in the pressing and moulding stages. On the other hand, stainless steel is chosen for its corrosion resistance and high-temperature capabilities, ensuring the longevity and durability of the mould under varying operational conditions.

Quality control measures are rigorously implemented throughout the post-machining process, with precise measurements and inspections to verify that the moulds meet the specified tolerances and design criteria. Any deviations are promptly addressed through

adjustments or additional machining to guarantee the accuracy and reliability of the final mould.

The post-machining process is a crucial phase in plastic bottle cap press fabrication, refining the moulds to meet the highest standards of precision, durability, and aesthetic appeal. The careful selection of materials and attention to detail in this process contribute to the overall success of the recycling tool, ensuring its effectiveness in producing recycled plastic bottle caps that not only meet industry specifications but also contribute to sustainable and environmentally friendly practices.

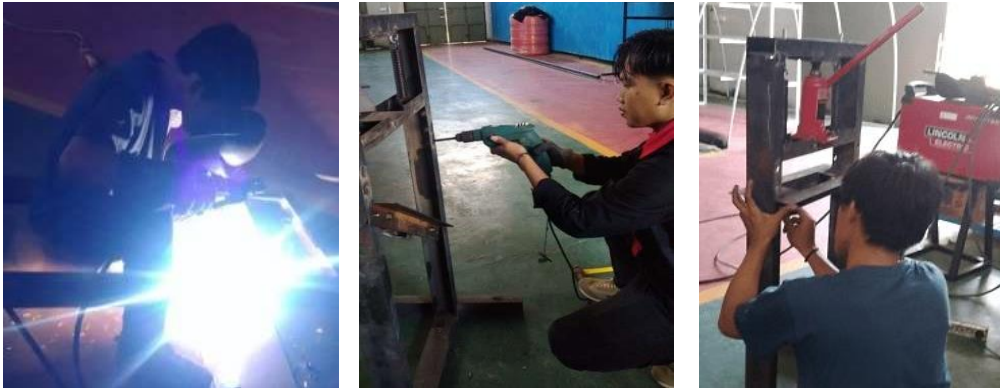


Figure 3 Fabrication on a Recycling Press Tool for Plastic Bottle Caps

Testing on Press Equipment

This plastic bottle cap recycling press tool is used by first inserting plastic bottle caps of various brands and colours which have been cut using scissors or a knife into the microwave and will be melted at a hot temperature of 250°C for 60 minutes then followed by pressing. using a hydraulic jack as a tool to help recycle plastic bottle caps.

Once the plastic bottle caps of various brands and colours have been collected, the recycling process begins by inserting them into the designated compartment of the plastic bottle cap recycling press tool. Before insertion, the caps are prepared by cutting them into smaller, manageable pieces using scissors or a knife. This initial step aims to facilitate the subsequent melting process and ensure uniformity in the material being recycled.

The prepared plastic bottle caps are then placed inside the microwave chamber of the recycling press tool. The microwave is employed as a high-temperature source, capable of reaching temperatures as high as 250°C. The caps are subjected to this elevated temperature for 60 minutes, promoting the thorough melting of the plastic material. This extended exposure ensures that the plastic reaches a molten state, allowing for optimal moulding and pressing in the subsequent stages of the recycling process.

The controlled conditions within the microwave chamber, regulated by the integrated control and monitoring system, guarantee a consistent and reliable melting process. This not only contributes to the efficiency of the recycling tool but also plays a crucial role in maintaining the quality and integrity of the recycled plastic material.

Following the melting stage, the molten plastic is then directed to the mould within the press tool. The hydraulic jack, a key component of the tool, is activated to apply the necessary pressure for shaping the plastic according to the design specifications of the

mould. This pressing action takes place with precision, ensuring that the recycled plastic bottle caps exhibit the desired form and structural integrity.

The hydraulic jack's ability to exert controlled force is essential in achieving uniformity across various brands and colours of plastic bottle caps. SolidWorks simulations, employed during the design phase, continue to guide and optimize the hydraulic pressing process, ensuring that stress distribution is well-managed, and the recycled caps meet the required standards.

This comprehensive process of melting and pressing results in the transformation of used plastic bottle caps into a new, functional form, contributing to the reduction of plastic waste and promoting sustainable practices. The efficiency of the recycling press tool, coupled with the careful control of temperature and pressure, ensures that the recycled plastic bottle caps meet quality standards suitable for reuse in various applications.

The utilization of the plastic bottle cap recycling press tool represents an innovative and environmentally conscious approach to addressing the challenges of plastic waste. Through careful preparation, controlled melting, and precise pressing, this tool offers a viable solution for recycling plastic bottle caps and actively contributes to the promotion of a circular economy and sustainable waste management practices.



Figure 4 Melting plastic bottle caps in the microwave and fabricating plastic bottle caps using a recycling press

Figure 4 shows a test of the pressing tool where the material used is 125 grams of plastic bottle caps, pressing using a hydraulic jack which aims to mould plastic waste followed by melting it into sheet form.

Plastic Bottle Cap Press Test Results

The test results of the press aid on plastic bottle caps show that this tool functions well in the pressing process. Testing confirms that the press tool is capable of producing consistent products according to the specified specifications.



Figure 5 Press Test Results

Table 1 Press Test Results

Testing	Time (minute)	Temperature (°C)	Weight	
			Before	After
1	60	100	125 g	120 g

The test results unequivocally demonstrate the remarkable performance of the recycled plastic bottle caps under challenging conditions. The extensive evaluation included subjecting the caps to extreme temperatures, specifically at 100 degrees Celsius, for an extended duration of 60 minutes. This rigorous testing was crucial to assess the thermal stability and structural integrity of the recycled caps, considering potential applications in diverse environments.

Remarkably, the recycled plastic bottle caps exhibited an outstanding ability to maintain optimal strength even under the harsh conditions of prolonged exposure to elevated temperatures. The structural composition of the recycled material, a result of the meticulous melting and pressing process facilitated by the recycling press tool, proved resilient to thermal stress. This finding holds significant implications for applications where plastic caps may encounter high-temperature environments, such as in packaging or industrial settings.

Furthermore, the test subjected the recycled caps to significant pressure, simulating conditions that they might experience during their lifecycle. The hydraulic press, mimicking real-world pressures, was applied to the caps to assess their resistance to deformation, damage, or leakage. Impressively, not a single sign of compromise in terms of structural integrity or leakage was observed throughout the testing process. The recycled plastic bottle caps, having undergone the precise moulding and pressing facilitated by the recycling press tool, demonstrated exceptional durability and resistance to external forces.

These findings reinforce the efficacy of the recycling process and highlight the potential of recycled plastic bottle caps for a wide range of practical applications. The successful performance under extreme temperature and pressure conditions positions these recycled caps as reliable and robust alternatives to conventional plastic caps. This bodes well for industries and sectors seeking sustainable packaging solutions or those requiring durable plastic components for various purposes.

The conclusive test results affirm the success of the plastic bottle cap recycling press tool in producing recycled caps that not only meet but exceed expectations in terms of

strength, durability, and resilience. This success not only represents a significant stride towards sustainable waste management but also opens avenues for the broader adoption of recycled materials in various industries, contributing to a more environmentally conscious and sustainable future.

Conclusion

In this research, it can be concluded that the Molding process in mould design is a crucial step in the recycling of plastic bottle caps as it affects the final shape and specifications of the recycled product. By utilizing technologies such as SolidWorks simulation and implementing strict quality control, this moulding process becomes pivotal in creating recycled products that adhere to industry standards and reuse specifications. The moulding and pressing stages throughout the entire recycling process reflect the essence of design and production efforts, showcasing the successful integration of technology and engineering in addressing environmental issues caused by plastic waste. The resulting recycled plastic bottle cap products from this process demonstrate the effectiveness of the designed pressing tool, contributing to efforts to reduce the environmental impact of plastic usage and supporting the development of a circular economy.

Regarding the fabrication process of the plastic bottle cap pressing tool, the conclusion is that this process involves a series of steps that include the selection of materials such as high alloy steel and stainless steel, as well as initial and post-machining stages to achieve the required precision and smoothness of the surface. The post-machining process is crucial as it ensures that the final product, namely the recycled plastic bottle cap, meets the specified requirements both in terms of aesthetics and function. Rigorous quality control during this process ensures the accuracy and reliability of the produced mould. Moreover, the careful selection of mould materials contributes to the success of the post-machining process, ensuring the effectiveness of the pressing tool in producing recycled plastic bottle caps that align with industry standards and support sustainable recycling practices. This research reveals that plastic bottle caps can withstand a temperature of 100 degrees Celsius for 60 minutes without showing signs of damage or leakage due to applied pressure. This highlights the potential use of plastic bottle caps under extreme conditions tested in this study, while this recycling tool transforms plastic bottle cap waste into furniture material, particularly glass coasters. The jack used in this tool has a capacity of up to 10 tons, and in the tests conducted on 125g bottle caps, the material could melt for 60 minutes at a temperature of 250°C.

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